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Development of Apical Pits in Chloride Cells of the Gills of 'Pimephales promelas' after Chronic Exposure to Acid Water

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DEVELOPMENT OF APICAL PITS IN CHLORIDE CELLS OF THE GILLS OF PIMEPHALES PROMELAS AFTER CHRONIC EXPOSURE TO ACID WATER

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16. ABSTRACT

Groups of 12 fathead minnows were exposed for 129 days to Lake Superior water acidified (pH 5.0, 5.5, 6.0 or 6.5) with reagent grade H_2SO_4 by means of a multichannel toxicant system for flow-through bioassays (1). Untreated water (pH 7.5) had the following properties: hardness 45.3 ± 0.3 (95% confidence interval) mg/l as $CaCO_3$; alkalinity 42.6 ± 0.2 mg/l; Cl^- 0.03 meq/l; Na^+ 0.05 meq/l; K^+ 0.01 meq/l; Ca^{2+} 0.68 meq/l; Mg^{2+} 0.26 meq/l; dissolved O_2 5.8 ± 0.3 mg/l; free CO_2 3.2 ± 0.4 mg/l; T= 24.3 ± 0.1°C. The 1st, 2nd and 3rd gills were subsequently processed for LM (methacrylate), TEM and SEM respectively.

Three changes involving chloride cells were correlated with increasing acidity: 1) the appearance of apical pits (figs. 2,5 as compared to figs. 1, 3,4) in chloride cells (about 22% of the chloride cells had pits at pH 5.0); 2) increases in their numbers and 3) increases in the % of these cells in the epithelium of the secondary lamellae. Some acid-exposed chloride cells, usually flattened ones in the secondary lamellae, exhibited bulbous apical evaginations (figs. 2,6) rather than apical pits.

Alterations in the apical morphology of chloride cells have often been described when euryhaline teleosts are transferred from fresh water (no pits) to salt water (pits develop). However, the reason for this transformation is not known (2). One common suggestion is that apical pits increase surface area for ionic exchanges. Pits may develop in chloride cells of acid-exposed fish as part of a mechanism to increase intake of Na^+ or Cl^- or efflux of H^+. Fish exposed to very low pH's tend to lose salts and to become acidotic. Chloride cells are thought to be involved in both ionic exchanges and acid-base balance.

In the present experiment, the rise in CO_2 concentration due to the addition of acid was not controlled (calculated free CO_2 at pH 5.0 was 41.4 ± 5.8 mg/l; dissolved O_2 was 6.0 ± 0.3 mg/l) so CO_2 could have had an effect on chloride cells. However, apical pits are also seen in gills of minnows from well-aerated acidified Lake Superior water and from experimentally acidified Canadian lakes with extremely soft water (Leino, preliminary observations). Therefore, CO_2 effects on chloride cells may be minimal, while H_2SO_4 may promote development of apical pits in these cells.

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Supported by a grant from the University of Minnesota Graduate School.

References

1. DeFoe, D. L. J. Fish. Res. Board Can. 32: 544-546, 1975.

2. Hossler, F. E. Am. J. Physiol. 238: R160-R164, 1980.

Figure Captions

Fig. 1. LM section of gill: non-acidified water (pH 7.5). The chloride cells, e.g., at arrow, usually have a flat or slightly convex apical surface partially covered by processes of pavement cells.

Fig. 2. LM section of gill: acidified water (pH 5.0), showing chloride cells with apical pits or apical evagination (arrow).

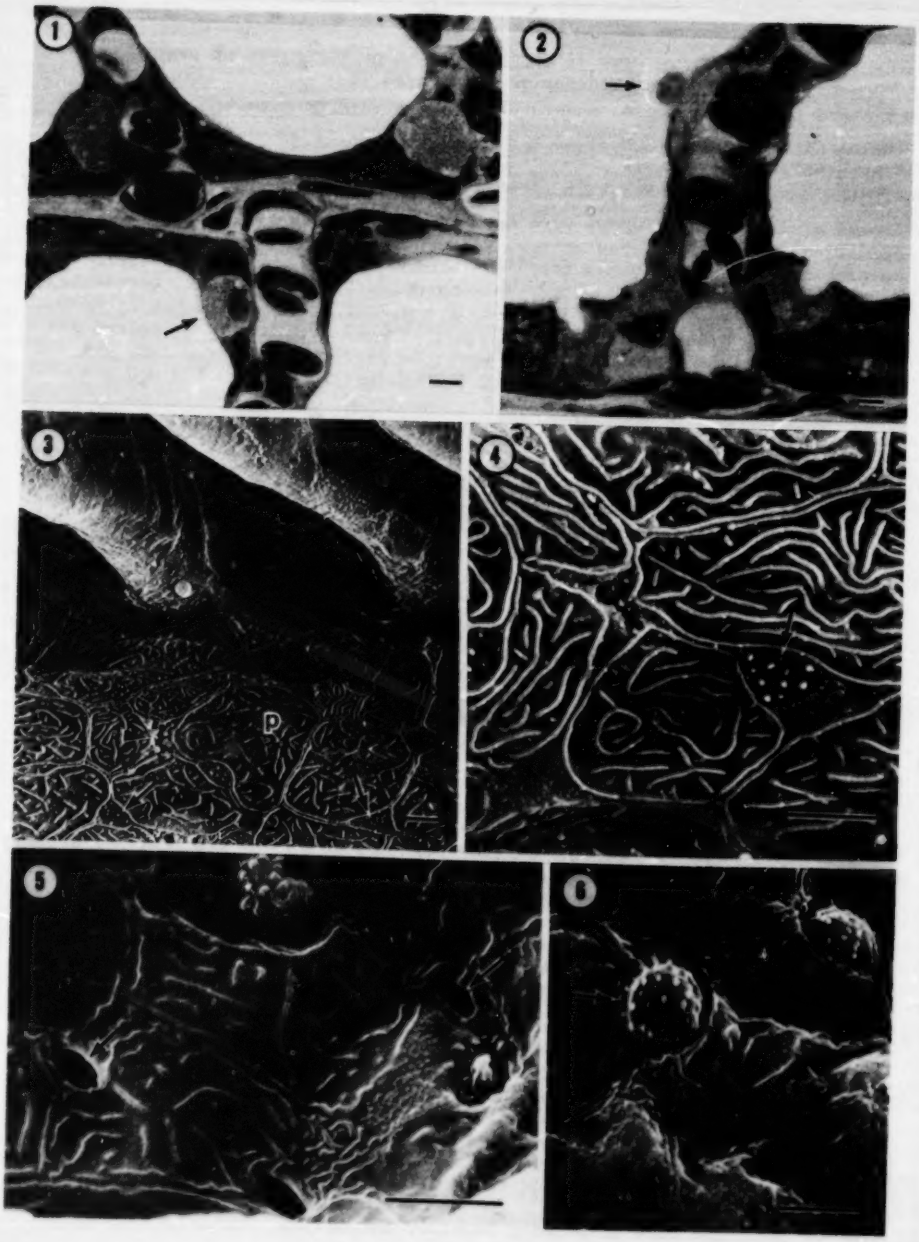
Fig. 3. SEM of primary lamellar epithelium: non-acidified water, showing surfaces of pavement (P), mucous (arrowhead) and chloride (arrows) cells. The exposed surfaces of chloride cells are flat and have a few short microvilli.

Fig. 4. Enlarged view of primary lamellar epithelium: non-acidified water, showing pavement, mucous and chloride cells (arrow).

Fig. 5. Primary lamellar epithelium: acidified water (pH 5.0), showing openings of apical pits (arrows) of chloride cells.

Fig. 6. Secondary lamellar epithelium: acidified water (pH 5.0), showing apical evagination (arrow) of a chloride cell.

Scale lines = 3 μm.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